A Meta-Analysis of Supplemental Enzyme Studies in Growing-Finishing Pigs Fed Diets Containing Dried Distillers Grains with Solubles: Effects on Growth Performance[1]

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Summary

A meta-analysis of 4 experiments involving 4,506 pigs was conducted to determine the effects of several commercial enzymes on the growth performance of growing-finishing pigs fed various amounts of dried distillers grains with solubles (DDGS). Experiments 1 and 2 used corn-soybean meal-based diets with 15% DDGS. A β-mannanase enzyme (Hemicell; ChemGen Corp., Gaithersburg, MD) was used in enzyme treatments in Exp. 1, and a blend of enzymes that had β-glucanase, cellulase, and protease activities (Agri-king REAP; Agri-King, Inc., Fulton, IL) was used in Exp. 2. In Exp. 3, diets containing 45% and 60% DDGS were fed with or without 2 commercial enzyme products designed for use in diets containing DDGS. In Exp. 4, an enzyme product with bacterial endo-1,4-β-xylanase was evaluated in diets containing 30% DDGS. All enzyme treatments in each experiment were pooled in a meta-analysis to compare the responses to diets with or without enzyme addition regardless of the other factors tested in each trial. All experiments were conducted in the same commercial swine research facility. There were no differences in ADG ($P > 0.52$), ADFI ($P > 0.33$), F/G ($P > 0.35$), and final weight ($P > 0.60$) among pigs fed diets with added enzyme and pigs fed diets without enzyme in any of the 4 experiments or in the pooled data. In conclusion, on the basis of the combined results from the 4 experiments evaluated in this meta-analysis, adding these enzymes in diets containing various amounts of DDGS does not appear to be beneficial in pigs.

Key words: dried distillers grains with solubles, enzyme

Introduction

The use of carbohydrate- and protein-degrading enzymes in livestock diets as an aid to improve nutrient utilization from plant-based ingredients has received a great deal of attention over the past decade. Studies conducted in poultry have consistently shown favorable results with the use of exogenous enzymes, but this has not been the case in pigs. Some experiments have reported beneficial effects of enzyme supplementation of diets on pig performance, but overall, results have been inconsistent. This suggests that the use of currently available enzymes may be better suited for poultry than pigs. Nevertheless, given the potential benefits of improved feed efficiency and high cost of feed, there is renewed interest in adding exogenous enzymes in swine diets.

[1] Appreciation is expressed to New Horizon Farms for use of pigs and facilities and to Richard Brobjorg, Scott Heidebrink, and Marty Heintz for technical assistance.

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The increased interest in enzyme use also has been fueled by the increasing use of less expensive alternative feed ingredients, most notably dried distillers grains with solubles (DDGS). Dried distillers grains with solubles have a high fiber content that is less digestible to the pig. Thus, there is potential to increase the nutritional value of DDGS by using exogenous enzymes to aid in breaking down fiber components. Experimental results suggest that DDGS can be fed to pigs only up to 30% in the diets before a decrease in performance is observed. The use of fiber-degrading enzymes provides an opportunity to maximize the value of DDGS for swine by improving its nutrient digestibility and could also potentially allow for higher inclusion rates of DDGS in swine diets. Therefore, we conducted a meta-analysis of data from 4 different experiments using various commercial enzyme products currently available in the market to determine the effects of these enzymes on the growth performance of growing-finishing pigs fed various amounts of DDGS.

Procedures

Procedures used in the experiments were approved by the Kansas State University Institutional Animal Care and Use Committee. The meta-analysis involved 4 different experiments using a total of 4,506 pigs of the same genetics (PIC L337 × C22). The first trial (Exp. 1) started on October 24, 2007, and the last trial (Exp. 4) ended on April 30, 2009. All experiments were conducted in a commercial swine research facility located in southwestern Minnesota. The barns were naturally ventilated and double curtain sided. Pens were 18 × 10 ft with completely slatted flooring and deep pits for manure storage. Each pen was equipped with a self-feeder and a cup waterer. Each barn had an automated feeding system (FeedPro; Feedlogic Corp., Willmar, MN) capable of delivering and recording data on feed amounts added on an individual pen basis.

Information regarding the 4 trials is shown in Table 1. In Exp. 1, a total of 1,269 pigs were assigned to treatments in a 2 × 2 × 2 factorial arrangement. The factors were Porcine Circovirus Type 2 vaccine dose (half or full), enzyme (with or without), and gender (barrow or gilt). The enzyme used was a commercially available β-mannanase (Hemicell; ChemGen Corp., Gaithersburg, MD). In Exp. 2, a total of 1,129 pigs were assigned to treatments in a 2 × 3 factorial arrangement. The factors were enzyme (with or without) and added fat (0%, 2.5%, or 5.0%). The commercial enzyme used was a proprietary blend of enzymes that had β-glucanase, cellulase, and protease activities (Agri-king REAP; Agri-King, Inc., Fulton, IL). In Exp. 1 and 2, DDGS was added at 15% in all dietary phases. In Exp. 3, a total of 1,032 pigs were allotted to a control treatment (30% DDGS) and 6 additional treatments in a 2 × 3 factorial arrangement based on DDGS level (45% or 60%) and enzyme used (none, product A, or product B). Enzymes used were commercial enzymes designed for use in diets containing DDGS. Regardless of treatment, levels of DDGS were reduced to 20% in all diets during the last 12 d of the experiment. In Exp. 4, a total of 1,076 pigs were assigned to 3 treatments: diets with 30% DDGS and 2% added fat with or without enzyme and a diet with 30% DDGS and 3% added fat without enzyme. The enzyme product used contained a bacterial endo-1,4-β-xylanase (Nutrase; Nutrex, Lille, Belgium). Regardless of treatment, levels of DDGS were reduced to 15% in the last dietary phase.

With the exception of Exp. 3, which was blocked by initial BW, pigs in all experiments were randomly assigned to treatments balanced by initial BW. In each experiment, all

enzyme treatments were pooled into 1 treatment (yes) to compare the responses to treatments without enzyme (no). Pen was the experimental unit in all trials. Data from the 4 experiments were then pooled, and statistical analysis was performed by analysis of variance using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with the fixed effect of enzyme (yes vs. no) and the random effects of trial and sex.

Results and Discussion

There were no differences in ADG ($P > 0.52$), ADFI ($P > 0.33$), F/G ($P > 0.35$), and final weight ($P > 0.60$) among pigs fed diets with or without added enzyme in any of the 4 experiments or in the pooled data (Table 2). These results are similar to a number of other experiments that did not find any significant impact of enzyme supplementation on pig growth performance.

In the first experiment, a commercially available enzyme with β-mannanase activity was used in corn-soybean meal-based diets with 15% added DDGS. However, the mannose fraction in DDGS, unlike in soybean meal, is present in very small amounts compared to the other carbohydrate fractions, which could limit the potential response of pigs to the enzyme used. This may be a plausible explanation for the absence of any response seen in Exp. 1. Because DDGS varies in carbohydrate composition and enzymes act on specific substrates, a combination of several enzymes that can act on various substrates present in DDGS might be a more logical approach. Using the same level of DDGS as in Exp. 1, a commercial enzyme blend known to act on and break down various carbohydrate fractions was used in corn-soybean meal-based diets in Exp. 2. Similar to the results obtained in Exp. 1, no significant improvement in growth performance was observed with the addition of the commercial enzyme product.

There are several possible explanations as to why results from enzyme supplementation in DDGS-containing diets have been inconsistent, including age of animal and amount of substrate. It has been reported that enzyme supplementation of diets containing 30% DDGS improved growth and feed efficiency in nursery pigs. In the commercial research facility where these 4 experiments were conducted, diets containing 30% DDGS fed to growing-finishing pigs have resulted in growth performance similar to that from corn-soybean meal-based diets without DDGS. Thus, we tested the effect of feeding higher levels of DDGS (45% to 60%) and whether enzyme supplementation, using two commercial enzymes designed for use in DDGS-containing diets, would help alleviate the negative effects of high levels of DDGS on growth performance. In theory, this significantly increases the amount of possible substrates for the enzymes to act on. However, similar to observations in the first 2 experiments, there was no significant effect of enzyme supplementation on growth performance of growing-finishing pigs, even with very high levels of DDGS.

In DDGS, non-starch polysaccharide arabinoxylans are present in greater proportions. Thus, using a product with xylanase activity can potentially increase the energy value of DDGS. In Exp. 4, we investigated the effect of a bacterial endo-1,4-β-xylanase on growth performance of pigs fed diets containing 30% DDGS. However, similar to the first 3 experiments, we did not observe any significant impact of enzyme supplementation on the growth performance of growing-finishing pigs.

In conclusion, adding these enzymes in diets containing DDGS as a means to improve nutrient and energy utilization does not appear to be beneficial in pigs, as measured by growth performance based on combined results from the 4 experiments. Even when some factors that affect enzyme efficacy, such as substrate specificity and level of DDGS, were addressed in the 4 experiments, the enzyme products used did not exert any positive effect on growth performance. At this point, it appears that use of these exogenous enzymes in corn-soybean meal-based swine diets containing high-fiber ingredients such as DDGS as a means to improve pig performance is not justified.

Table 1. Details of individual experiments included in the meta-analysis[1]

Experiment	Duration, d	Experimental units, n	Start weight, lb	DDGS[2], %	Enzyme activity of product used	Reference
1	92	47	65.3	15	β-mannanase	
2	56	42	75.8	15	β-glucanase, cellulase, and protease	Jacela et al., 2008[3]
3	90	42	101.5	45 and 60	Proprietary blend of enzymes	Jacela et al., 2009[4]
4	66	39	87.4	30	Bacterial endo-1,4- β-xylanase	Jacela et al., 2009[5]

[1] Data from 4 experiments involving 4,506 pigs.
[2] Dried distillers grains with solubles.
[3] Jacela et al., Swine Day 2008, Report of Progress 1001, pp. 111-116.
[4] Jacela et al., Swine Day 2009, Report of Progress 1020, pp. 192-201.
[5] Jacela et al., Swine Day 2009, Report of Progress 1020, pp. 207-212.

Table 2. Effect of enzyme addition to diets containing DDGS on growth performance of growing-finishing pigs[1]

	Final wt, lb			ADG, lb			ADFI, lb			F/G		
Experiment	Control	Enzyme	SED[2]	Control	Enzyme	SED	Control	Enzyme	SED	Control	Enzyme	SED
1	266.6	266.9	1.78	2.21	2.22	0.016	5.42	5.47	0.054	2.45	2.46	0.016
2	192.7	192.2	1.99	2.08	2.07	0.016	4.93	4.94	0.066	2.37	2.38	0.031
3	269.4	268.9	3.20	1.89	1.88	0.021	5.11	5.05	0.062	2.71	2.69	0.021
4	210.4	208.3	4.08	1.82	1.81	0.035	4.66	4.66	0.118	2.57	2.58	0.030
avg.	234.8	234.2	1.34	2.00	2.00	0.010	5.03	5.03	0.033	2.52	2.52	0.012

[1] Data from 4 experiments involving 4,506 pigs. In each experiment, pigs fed enzyme-supplemented diets were compared with pigs fed diets without enzyme regardless of other factors being tested in the experiment. There was no significant difference ($P > 0.33$) between control and enzyme supplementation for any response criteria either within individual experiments or overall when data from all experiments were pooled together.
[2] Standard error of the difference.